Detrusor acontractility after acute spinal cord injury: Myth or reality?

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Abstract: PURPOSE We assessed urodynamic parameters within the first 40 days after spinal cord injury (SCI) investigating whether the detrusor is acontractile during the acute phase of SCI. PATIENTS AND METHODS We performed a prospective cohort study including 54 patients with neurogenic lower urinary tract dysfunction (NLUTD) due to acute SCI undergoing urodynamic investigation (UDI) within the first 40 days after injury at a single university SCI center. RESULTS and Limitations: Of the 54 patients, UDI revealed an acontractile detrusor in only 20 (37%) but unfavorable urodynamic parameters in a total of 34 (63%) patients. Detrusor overactivity was found in 32 patients, detrusor sphincter dyssynergia in 25, maximum storage detrusor pressure >40cmH2O in 17, vesico-uretero-renal reflux in 3 and low bladder compliance (<20mL/cmH2O) in 1 patient (more than one unfavorable urodynamic parameter possible). CONCLUSIONS In contrast to the common notion of an acontractile detrusor during acute SCI, almost two-thirds of our patients showed unfavorable urodynamic parameters within the first 40 days after SCI. Considering that early treatment of NLUTD in patients with acute SCI might improve long-term urological outcome, UDI should be performed timely to optimize patient-tailored therapy.

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Detrusor Acontractility after Acute Spinal Cord Injury—Myth or Reality?

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Purpose: We assessed urodynamic parameters within the first 40 days after spinal cord injury to investigate whether the detrusor is acontractile during the acute phase of spinal cord injury.

Materials and Methods: We performed a prospective cohort study in 54 patients with neurogenic lower urinary tract dysfunction due to acute spinal cord injury who underwent urodynamic investigation within the first 40 days after injury at a single university spinal cord injury center.

Results: Urodynamic investigation revealed an acontractile detrusor in only 20 of the 54 patients (37%) but unfavorable urodynamic parameters in 34 (63%). We found detrusor overactivity in 32 patients, detrusor-sphincter dyssynergia in 25, maximum storage detrusor pressure greater than 40 cm H_2O in 17, vesicoureteral reflux in 3 and low bladder compliance (less than 20 ml/cm H_2O) in 1. More than 1 unfavorable urodynamic parameter per patient was possible.

Conclusions: In contrast to the common notion of an acontractile detrusor during acute spinal cord injury, almost two-thirds of our patients showed unfavorable urodynamic parameters within the first 40 days after spinal cord injury. Considering that early treatment of neurogenic lower urinary tract dysfunction in patients with acute spinal cord injury might improve the long-term urological outcome, urodynamic investigation should be performed timely to optimize patient tailored therapy.

Key Words: urinary bladder, neurogenic; urodynamics; spinal cord injuries; muscle hypotonia

Abbreviations and Acronyms

AIS = American Spinal Cord Injury Association Impairment Scale

ICS = International Continence Society

NLUTD = neurogenic lower urinary tract dysfunction

SCI = spinal cord injury

UDI = urodynamic investigation

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Neurogenic lower urinary tract dysfunction impairs health related quality of life and imposes a significant risk of lower and upper urinary tract function in patients with SCI.[1,2] Particularly high detrusor pressure (greater than 40 cm H_2O) during the storage phase[3] caused by a low compliance (less than 20 ml/cm H_2O)[4] bladder and/or detrusor overactivity with detrusor-sphincter dyssynergia might result in irreversible structural changes of the lower and upper urinary tract. This can result in deteriorating renal function and even lead to terminal renal failure. To detect such alterations regular neurourological followup with UDI is important,[5] particularly because those conditions might develop silently with time.[2]

In contrast to chronic SCI, little is known about lower urinary tract function during the acute phase of SCI. This is because UDI is usually postponed to the chronic SCI phase since the detrusor is a priori considered acontractile, which might delay

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adequate treatment. Therefore, we assessed urodynamic parameters in the acute phase of SCI.

PATIENTS AND METHODS

Patients

From January 2012 to December 2015 we prospectively evaluated a consecutive series of 54 patients, including 13 women and 41 men, with acute SCI at our institution. Study inclusion criteria were NLUTD due to SCI and UDI within the first 40 days after SCI, ie within the very acute or acute phase 1 of SCI according to EMSCI (European Multicenter Study about Spinal Cord Injury) definitions. Patients younger than 18 years, pregnant and breast feeding women, and patients with a current urinary tract infection were excluded from analysis. The study was approved by the local ethics committee and all participants provided written informed consent.

All methods, definitions and units are presented according to the standards recommended by ICS.[6,7] SCI neurological level and completeness, ie sensorimotor impairment, were determined using AIS according to ISNCSCI (International Standards for Neurological Classification of Spinal Cord Injury).[8]

Neurourological Evaluation

All patients underwent neurourological assessment as described previously.[1] UDI was performed as videourodynamics with a combination of filling cystometry and pressure flow study if spontaneous voiding was possible, with fluoroscopy as recommended by the EAU (European Association of Urology) guidelines on neuro-urology[2] and according to good urodynamic practices following ICS recommendations.[7,9,10] The bladder was filled with a body warm (36C) mixture of 0.9% sodium chloride solution and contrast medium at a speed of 20 ml per minute with the patient sitting when possible. Continuous cardiovascular monitoring with a Finometer® PRO was applied to enable a nonstop beat-to-beat documentation of systolic blood pressure, diastolic blood pressure and heart rate synchronous to the ongoing UDI.

In case of autonomic dysreflexia, defined according to ISAFSCI (International Standards to document remaining Autonomic Function after SCI) as an increase in systolic blood pressure 20 mm Hg or greater from baseline,[11] UDI was stopped immediately and the bladder was emptied. Detrusor-sphincter dyssynergia was defined as 1) detrusor contraction concurrent with involuntary contraction of the urethral and/or periurethral striated muscle[6,7] on pelvic floor electromyography in the absence of the Valsalva or Credé maneuver and/or 2) a dilated posterior urethra obstructed by the external urethral sphincter on fluoroscopy during videourodynamics as described previously.[12] Patients with asymptomatic bacteriuria were not treated and no antibiotic prophylaxis was administered for UDI.

Outcome Measures

Outcome measures were urodynamic findings within the first 40 days after SCI. Unfavorable urodynamic parameters were defined as detrusor overactivity, detrusor-sphincter dyssynergia, maximum storage detrusor pressure greater than 40 cm H_2O,[3] bladder compliance less than 20 ml/cm H_2O[4] and vesicoureteral reflux of any grade.

Statistical Analyses

Urodynamic data were approximately normally distributed and are presented as the mean ± SD. We used Stata®/MP, version 13.0 for statistical analyses.

RESULTS

Table 1 lists patient characteristics. Mean age at SCI was 50 ± 17 years, including 47 ± 18 and 51 ± 17 years in female and male patients, respectively. Of the 54 patients 41 (75%) were men, 15 (28%) had complete SCI (AIS A), 27 (50%) had a thoracic lesion, 44 (82%) emptied the bladder via an indwelling catheter and 52 (96%) were receiving no bladder medication at the time of UDI.

Table 1 also shows urodynamic findings within the first 40 days after SCI. UDI revealed an acontractile detrusor in only 20 of the 54 patients (37%) but unfavorable urodynamic parameters in 34 (63%). Table 2 lists unfavorable urodynamic findings in relation to AIS and lesion level.

Table 1. *Patient characteristics and urodynamic findings*

No. pts	54	
Mean ± SD age at SCI (range)	50 ± 17	(21–78)
No. female (%)	13	(24)
No. male (%)	41	(75)
No. AIS (%):		
A	15	(28)
B	8	(15)
C	13	(24)
D	18	(33)
No. injury level (%):		
Cervical	15	(28)
Thoracic	27	(50)
Lumbar	12	(22)
Mean ± SD days injury to UDI (range)	28 ± 6	(13–39)
No. bladder emptying at UDI (%):		
Spontaneous voiding	0	
Spontaneous voiding + intermittent self-catheterization	6	(11)
Only intermittent self-catheterization	4	(7)
Indwelling catheter	44	(82)
No. bladder medication at UDI (%):		
None	52	(96)
Antimuscarinic drug	1	(2)
α-Blocker	1	(2)
Filling cystometry:		
No. pts	54	
Mean ± SD ml max cystometric bladder capacity (range)	653 ± 282	(190–1,600)
Mean ± SD ml/cm H_2O bladder compliance (range)	106 ± 113	(8–600)
Mean ± SD cm H_2O max storage detrusor pressure (range)	30 ± 26	(3–111)
Pressure flow study:		
No. pts	13	
Mean ± SD ml/sec max flow rate (range)	15 ± 10	(3–35)
Mean ± SD cm H_2O max voiding detrusor pressure (range)	69 ± 37	(26–124)
Mean ± SD ml voided vol (range)	297 ± 229	(30–650)
Mean ± SD ml post-void residual vol (range)	310 ± 373	(0–1,100)

Table 2. *Unfavorable urodynamic parameters by AIS and lesion level*

Category	No. Pts	No. Detrusor Overactivity	No. Detrusor-Sphincter Dyssynergia	No. Max Storage Detrusor Pressure Greater Than 40 cm H_2O	No. Bladder Compliance Less Than 20 ml/cm H_2O	No. Vesicoureteral Reflux
Overall	54	32	25	17	1	3
AIS category:						
A	15	11	10	5	0	1
B	8	4	6	2	0	2
C	13	8	6	4	0	0
D	18	9	3	6	1	0
Lesion level:						
Cervical	15	11	10	5	0	1
Thoracic	27	15	14	8	0	2
Lumbar	12	6	1	4	1	0

One patient may have had more than 1 unfavorable urodynamic parameter.

In 1 patient with a C7 lesion autonomic dysreflexia occurred. UDI was stopped immediately and the bladder was emptied. This event did not cause a complication.

DISCUSSION

Main Findings

In our prospective study in 54 patients with acute SCI almost two-thirds showed unfavorable urodynamic parameters within the first 40 days after SCI, disproving the myth of detrusor acontractility after acute SCI. About 6 of 10 patients showed detrusor overactivity, almost a third had a high pressure system with storage detrusor pressure greater than 40 cm H_2O, jeopardizing the upper urinary tract, and in 6% vesicoureteral reflux was detected.

Findings in Context of Existing Evidence

The initial phase following acute SCI is that of spinal shock.[13] This is related to the loss or the depression of most spinal reflex activity below the level of injury.[14] Spinal shock is thought to result from the sudden withdrawal of facilitatory descending input from the supraspinal tracts, which disrupts transmission at synapses and stops interneuronal conduction in the distal cord.[14] The loss of skeletal reflexes leads to flaccid paralysis and the loss of deep tendon reflexes. In addition to the effects on skeletal muscle, spinal shock may result in an acontractile detrusor.

The duration of spinal shock varies widely from several days to several months. It is not an all or nothing entity but instead depends on spinal lesion extension and completeness. However, there is no generally accepted definition of spinal shock and to our knowledge there are no high level evidence studies on this issue. Nevertheless, Ditunno et al proposed a spinal shock model which is helpful in understanding this phenomenon.[15] It includes an initial phase of loss of reflexes and 3 subsequent recovery phases.

Reports on urodynamic data during the acute phase of SCI are limited. Rossier et al reported a historical series of 17 patients with complete SCI, including 13 with tetraplegia and 4 with paraplegia, who underwent UDI 1 to 28 days after injury.[16] The investigators did not find any vesical activity. Watanabe et al reported urodynamic parameters in patients with acute SCI within 2 weeks after injury and found NLUTD in 41% with the mildest form of incomplete SCI (AIS E).[17] These findings highlight the difficulty of deducing vegetative from somatic function as well as the poor accuracy of AIS in predicting NLUTD.

In a large cross-sectional study of 243 patients with chronic SCI who had a mean injury history of 18 years Weld and Dmochowski reported that somatic and urodynamic findings correlated imprecisely.[18] Moreover, a study at our center previously revealed that ambulatory and nonambulatory patients with acute SCI were at similar risk for unfavorable urodynamic parameters.[19] Therefore, complete neurourological assessment including UDI is strongly recommended in all patients with acute SCI regardless of the ability to walk. In addition, same session repeat UDI is crucial in clinical decision making since repeat measurements may yield completely different results.[20]

Implications

Practice. The principal aim of treating patients with NLUTD due to SCI is protecting the upper urinary tract and improving disease related quality of life. Thus, UDI is necessary to identify risk factors which jeopardize the upper urinary tract and guarantee optimal patient tailored therapy.

During the last decades intermittent self-catherization and antimuscarinics have substantially improved outcomes in patients with SCI in terms of morbidity and mortality due to the decrease in urological complications.[21–23] Despite these improvements patients in the early stage after SCI are still treated with indwelling catheters and

treatment is often deferred until the chronic phase. However, we observed a high incidence of unfavorable urodynamic parameters within the first 40 days after injury.

Although acute kidney injury is uncommon after SCI, if unfavorable urodynamic parameters are left untreated, it might lead to chronic kidney disease, urinary tract infection and low quality of life due to urinary incontinence. Considering that early diagnosis and treatment[24] could have an important role in the long-term urological outcome in patients with NLUTD due to SCI, we recommend early, proactive neurourological management in SCI cases before the chronic phase of the disease is reached.

In addition, it seems reasonable to start appropriate treatment as early as possible without waiting for the irreversible complications of the disease. In patients with unfavorable urodynamic parameters followup UDI should be considered 1 to 3 months after treatment initiation (eg antimuscarinics, neuromodulation, intradetrusor onabotulinumtoxinA injections, etc) to assess the therapeutic effects and adjust treatment if needed. Special attention should be given to appropriate standardization of the urodynamic technique since this is the prerequisite for reproducible and reliable results. Thus, performing and reporting UDI in accordance with ICS standards[9,10] is strongly recommended.

Research. There has been considerable interest in trying to prevent neurourological complications with interventions early after SCI. In a small series 10 patients with complete suprasacral SCI were treated with early sacral neuromodulation 1 to 4 months after injury.[24] At subsequent followup there were preserved bladder compliance, no detrusor overactivity, and improved bowel and erectile function compared with patients with SCI who were untreated. Similarly, animal studies demonstrated that early medication,[25] intradetrusor onabotulinumtoxinA[26] and neuromodulation[27] can modify long-term urinary tract function after SCI. Moreover, registered clinical trials have been done to further evaluate the ability of early intradetrusor onabotulinumtoxinA injections (ClinicalTrials.gov NCT00711087 and NCT01698138) and early sacral neuromodulation (ClinicalTrials.gov NCT03083366) to preserve lower and upper urinary tract function, and prevent the complications associated with NLUTD.

Because the somatic and autonomic systems are close to each other in the spinal cord, a strong association between lower urinary tract function and somatomotor function might be expected.[28] Indeed, based on data on 1,250 patients in the European Multicenter Study about Spinal Cord Injury we recently found that lower extremity motor score assessed within the first 40 days after SCI can reliably predict urinary continence and complete bladder emptying 1 year after injury.[29] Thus, correlating early urodynamic findings with somatomotor and neurophysiological data might further enhance our understanding of different clinical patterns and NLUTD evolution after SCI.[29]

In addition, it would be relevant to learn how urodynamic findings evolve with time and which parameters finally result in lower and upper urinary tract complications at subsequent followup. Therefore, further prospective investigations are highly warranted.

Study Limitations

Some limitations of the current study should be considered. Our unit is part of a highly specialized university SCI center where probably the most severe cases are treated. Thus, since the incidence of unfavorable urodynamic parameters could be lower in a less select patient group, negative selection bias cannot be completely ruled out. Moreover, subgroup analyses to investigate risk factors for unfavorable urodynamic parameters were not possible due to the limited number of study patients. Finally, the design and setup of this study made us unable to assess the efficacy of early vs late neurourological treatment. According to our data the merit of early UDI with consequent early neurourological treatment, if needed, seems plausible but this must be assessed in a randomized controlled trial.

CONCLUSIONS

Although it is generally assumed that patients with SCI have an acontractile detrusor during the acute phase after injury, we found detrusor overactivity in about 6 of 10 patients within the first 40 days after SCI. Overall almost two-thirds of our patients showed unfavorable urodynamic parameters which jeopardized the lower and upper urinary tract. Thus, UDI performed as early as possible after spinal trauma appears to be rational SCI management. Moreover, early treatment based on urodynamic findings might improve the urological outcome in patients with SCI and so also reduce overall costs. Insurance companies should become interested in UDI reimbursement to finally save resources by proactive neurourological management, including the start of appropriate treatment as early as possible without waiting for the irreversible complications of the disease.

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EDITORIAL COMMENT

Most urologists have assumed the dogma that the first few months of neurological spinal shock are associated with an atonic detrusor muscle. This assumption has likely persisted because patients with a neurological diagnosis such as SCI generally never interact with a urologist until they have clinically manifested bladder related problems.

While this study is merely descriptive, it offers intriguing support for further research into the neuroplasticity of NLUTD in those early months after SCI. Specifically, if NLUTD develops so early after SCI, can we intervene during that critical window to prevent it? The SCI community has been challenged with restoring ambulation so it would be unlikely that urologists would be able to restore the normal micturition cycle. But what if we could prevent the onset of detrusor overactivity and poor compliance? These conditions currently require chronic management with antimuscarinics with a

risk of side effects, including possible dementia,[1] or repeat botulinum toxin injections.

If we could make the bladder a low pressure storage vessel, we would only need to facilitate a method of bladder emptying. Studies like this provide impetus for introducing urologists in those early months after SCI.

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